WAVES (Water Vapor Validation – Satellite/Sondes)

Results from 2006 and plans for 2007

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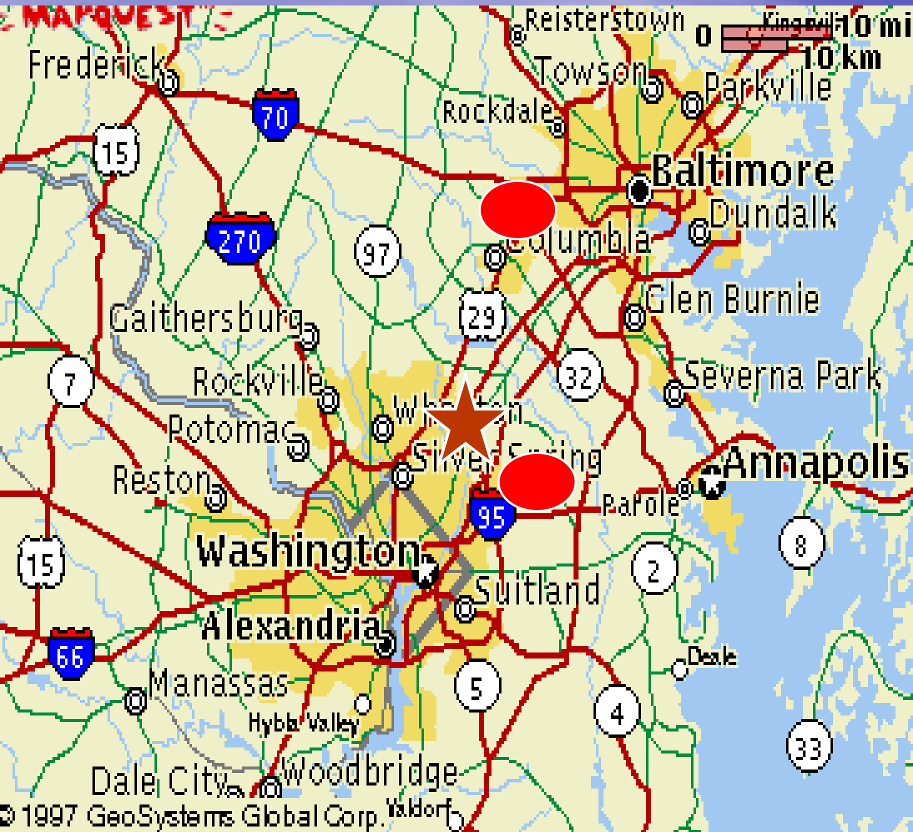
The Howard University Beltsville Research Campus



- **A semi-urban field site**
  - **Mid-Atlantic, urban experiences a wide range of meteorological conditions**
  - **Provides environment very different than ARM sites**
- **Difficult retrieval site**
  - **heterogeneous terrain**
  - **summertime polluted conditions**
- **Good for validation case studies representative of urban, polluted conditions**
  - **how good are the retrievals in the vicinity of the US capitol and where millions of people live?**
- **Good location for inter-agency collaboration and education**

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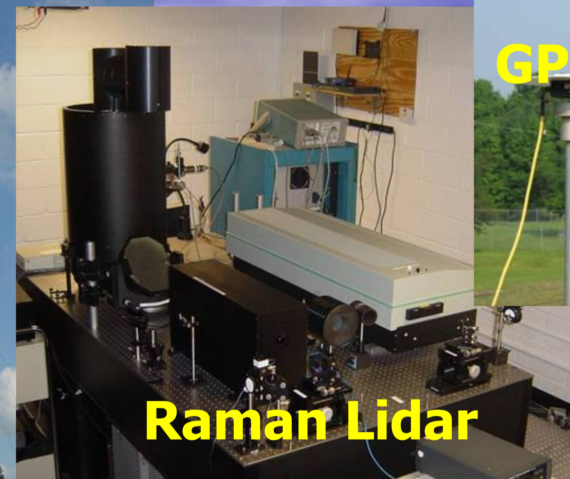
NASA NOAA MDE HOWARD UNIVERSITY METEOROLOGY UMBC PENNSTATE

Beltsville Campus Instrumentation

Aerosol-Cloud-Radiation

Atmosphere-Surface



Air Quality

Integrating Research and Student Training

Ozonesonde launch

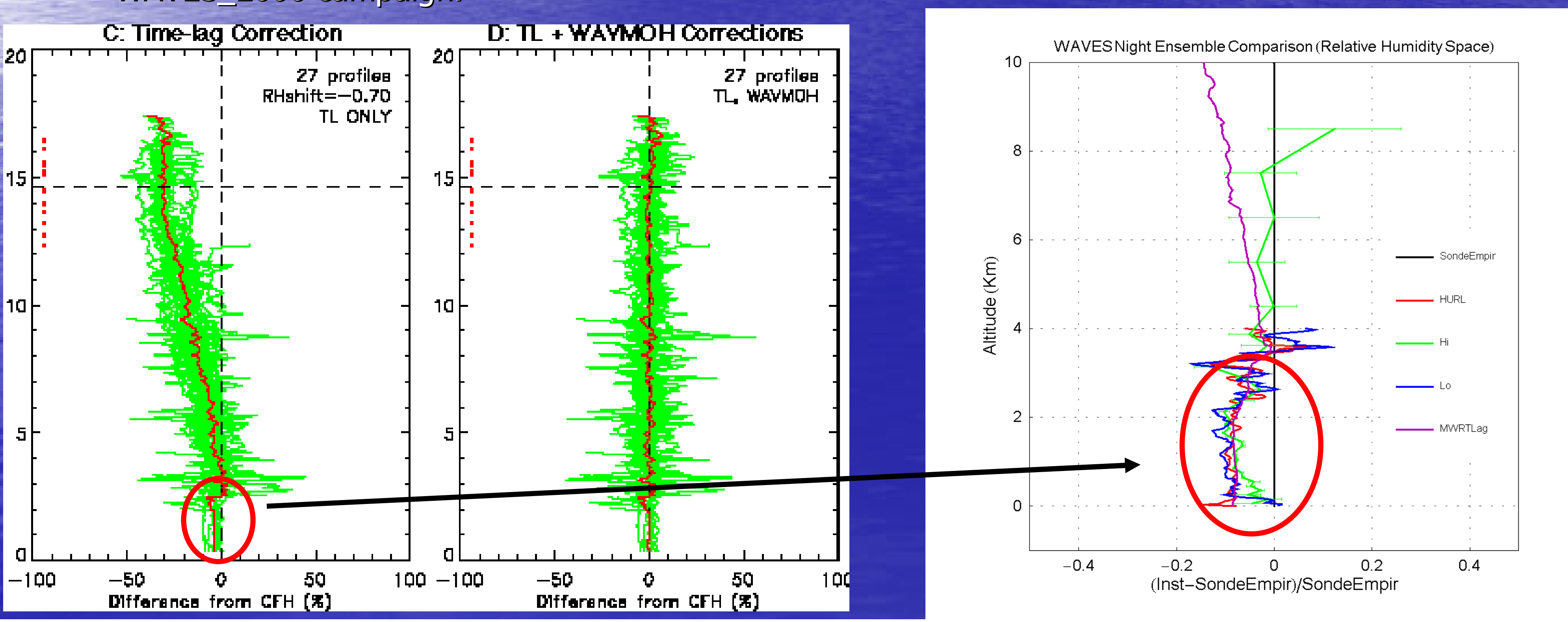
Lidar operations

WAVES_2006 (June 27 – August 12, 2006)

- Goals
  - Provide water vapor and ozone validation data for Aura/Aqua
  - Assess current calibration of RS92
  - Assess UT water vapor measurements of Raman lidar systems
    - Work upported by Network for Detection of Atmopsheric Composition Change (NDACC) in preparation for MOHAVE campaign at JPL in Oct, 2006.
  - Study regional water vapor/aerosol variability and influence on satellite retrievals
- Operations
  - ~35 A-train overpasses covered
    - 143 sondes including 15 CFHs, 35 ozonesondes and 7 technologies of PTU sensors (coordinated with overpasses)
    - Coordinated operations with 7 lidar systems (5 Raman and 2 backscatter)
      - Water vapor, aerosols, temperature
- Analysis status
  - Updated empirical correction for RS-92 sondes.
    - Investigation of possible CFH moist bias in lower atmosphere
  - Wide range of water vapor calibrations found
  - Joint AIRS, TES, sonde case study comparison involving Howard University, NOAA, JPL, GSFC in process

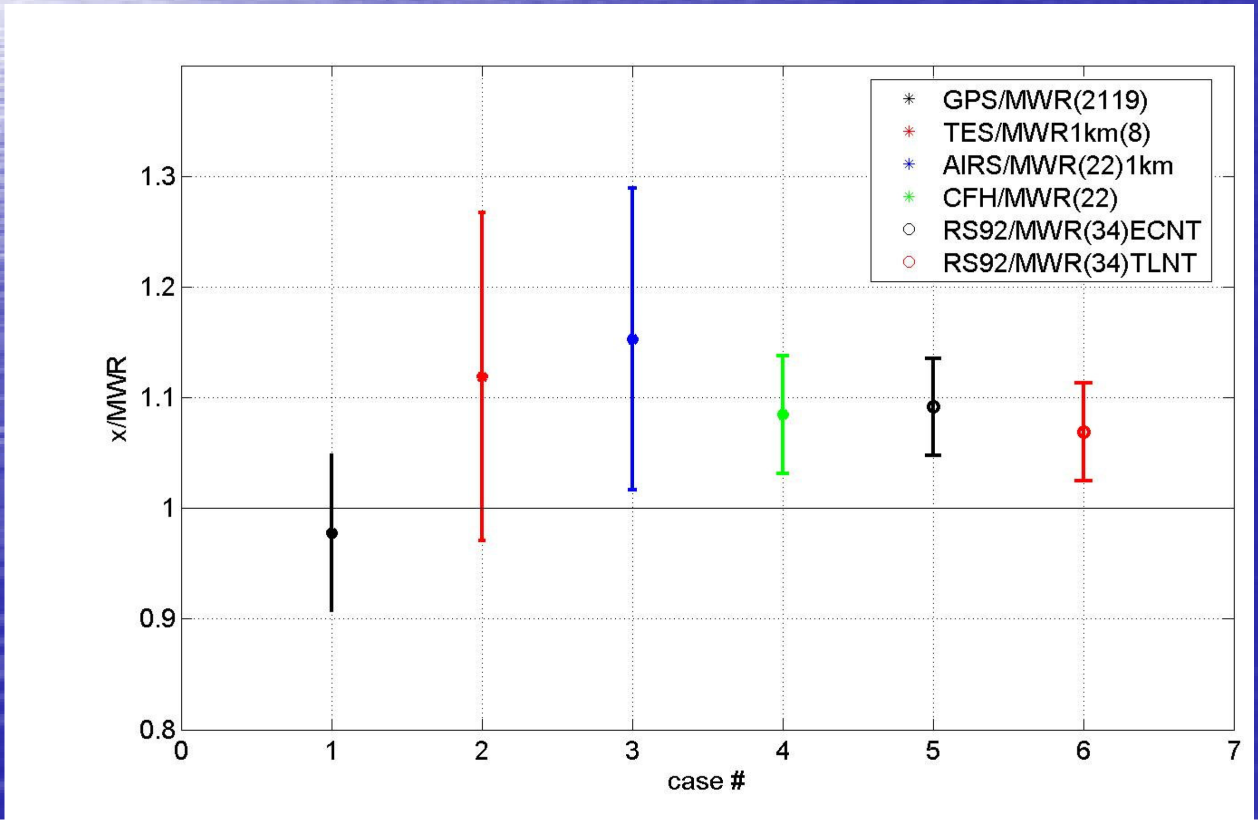
Empirical Corrections for Vaisala RS-92 RH

- Regular study of radiosonde performance required due to (un-announced) calibration changes. Recent Vaisala RS-92 calibration changes
    - June, 2001
    - June, 2004
- Only nighttime data shown here.
    - Avoid solar radiation issue which is significant and dependent on sun angle and cloud amount
- Standard Miloshevich technique is to develop empirical correction based on same-balloon comparisons with Cryogenic Frostpoint Hygrometer (CFH)
    - Plots on left show step prior to empirical correction and the magnitude of correction.
    - Significant RS92 UT dry bias without correction.
- However, the comparison of two independent lidar profiles shows similar signature to uncorrected RS92
    - Implication seems to be a 5-10% moist bias in CFH measurements in the lowest 4 km during the WAVES_2006 campaign.

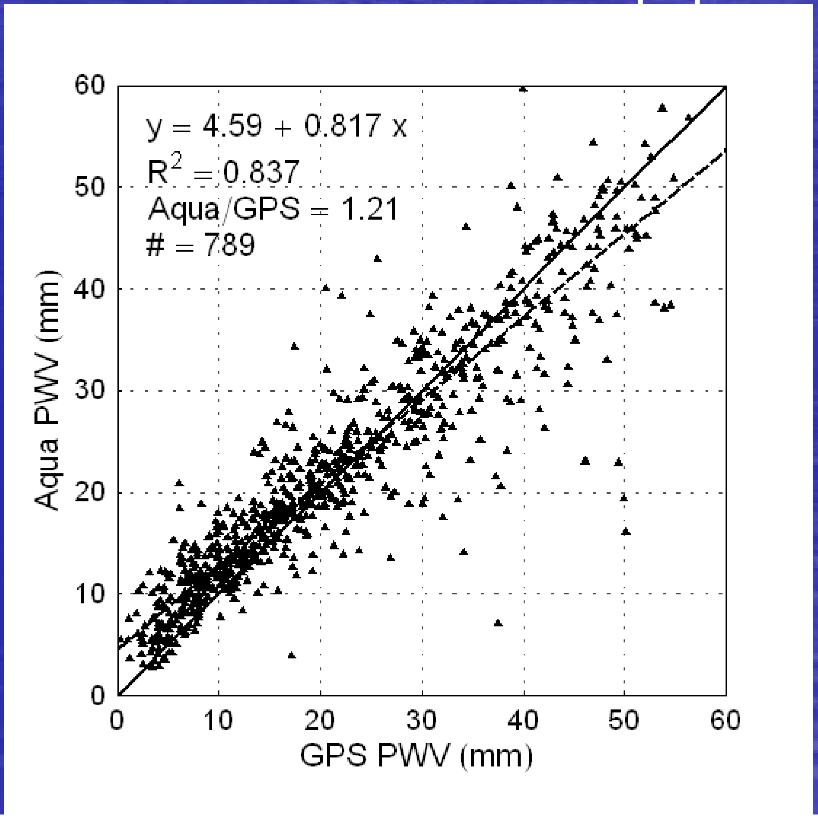


PW Calibrations

- One standard way to compare overall water vapor calibration is to compare precipitable water over a column set of altitudes/pressures
  - Permits comparison with the ARM "gold standard" – the microwave radiometer
  - Previous such comparisons (AFWEX, AWEX) have achieved agreement at the ~5% level
- WAVES calibration comparison shows ~20% range of PW calibrations.
- AIRS and TES biased high with respect to MWR and GPS
  - Similar results to those reported in AIRS validation special section



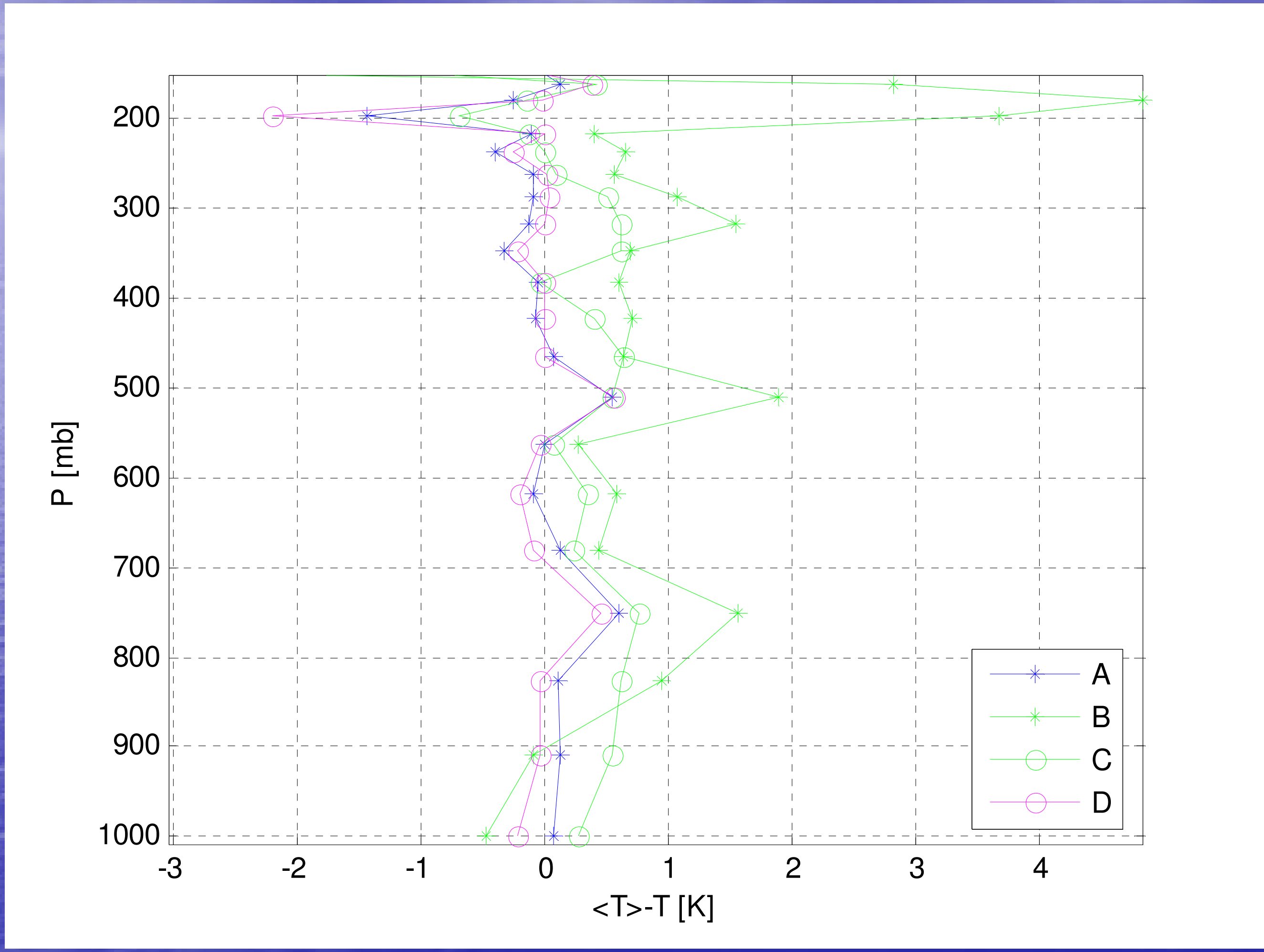
Results from validation paper



WAVES Intercomparison Study

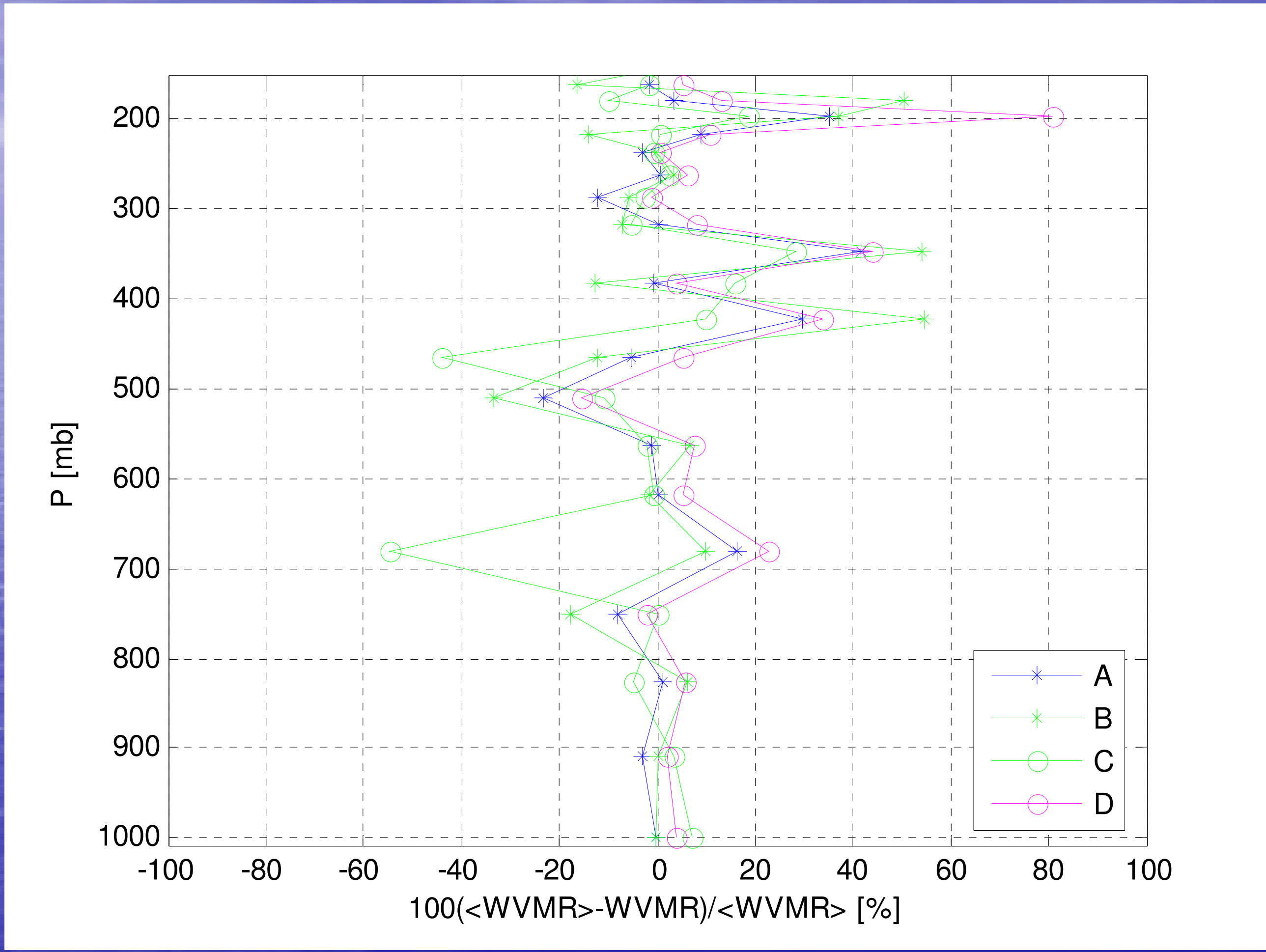
- Initial comparison of WAVES water vapor and ozone sondes with AIRS and TES retrievals, performed by different people, did not necessarily lead to same conclusions
  - Sub-group formed to study methods of comparison with the goal of coming to common agreement on how to intercompare AIRS and TES with validation data (either sonde or lidar)
  - Group members from Howard University, NOAA, JPL, AER, NASA-GSFC
- Start by selecting a single case where CFH, RS92, TES, AIRS and lidar all operating.
- Focus on the first step of interpolating sonde data to either the 67 levels of TES or 100 layers of AIRS.
- What is shown here is a comparison of several profiles showing interpolation of sonde data to TES 67 levels (AIRS results weren't ready in time for this presentation). The baseline profile is one determined through a constraining interpolation:
  - For the case of water vapor or ozone, the total number of molecules must be preserved layer by layer
  - For the case of temperature, the mean radiating temperature of layers must be preserved

WAVES Intercomparison Study



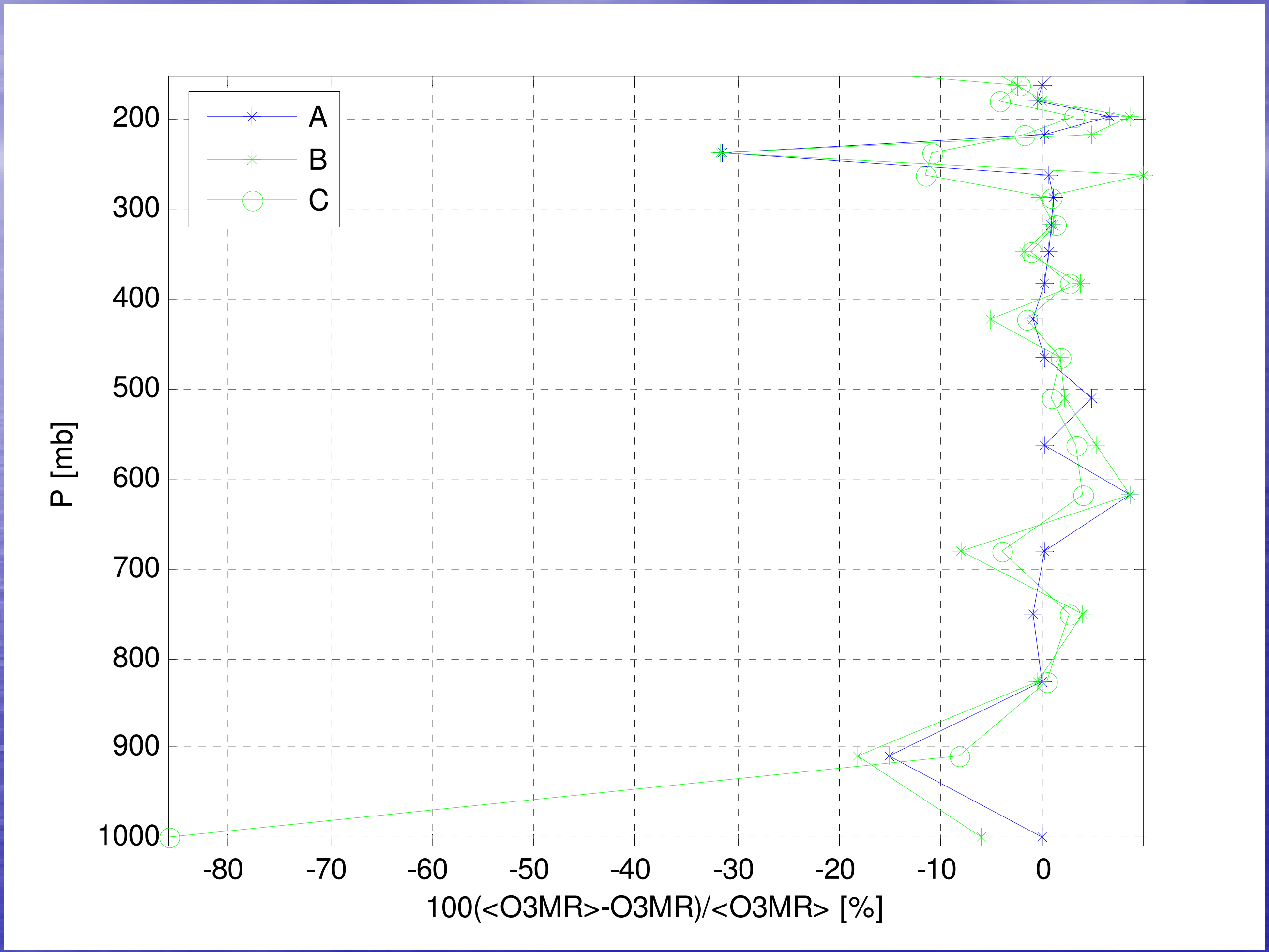
Interpolated temperatures differ by 0.5 - 1 K frequently

WAVES Intercomparison Study



Interpolated water vapor mixing ratios frequently differ by more than 20%

WAVES Intercomparison Study



Interpolated ozone mixing ratios agree generally within 10-20% except at surface and 250 mb.

WAVES Intercomparison Study

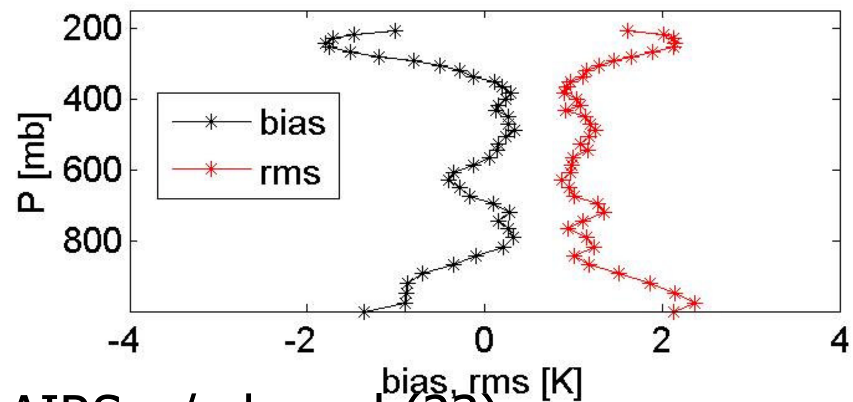
- Comments
  - It is surprisingly tricky to interpolate sonde data onto satellite pressure levels
    - Multiple advanced degrees represented in the results shown…
  - These results were plotted up for the first time on Monday of this week
    - These are the first presentation of these results to the group
    - We will be discussing soon so as to reduce the range of results
  - GOAL : Define a common procedure for both TES and AIRS for performing this important step in satellite data validation

Ensemble comparisons from WAVES_2006

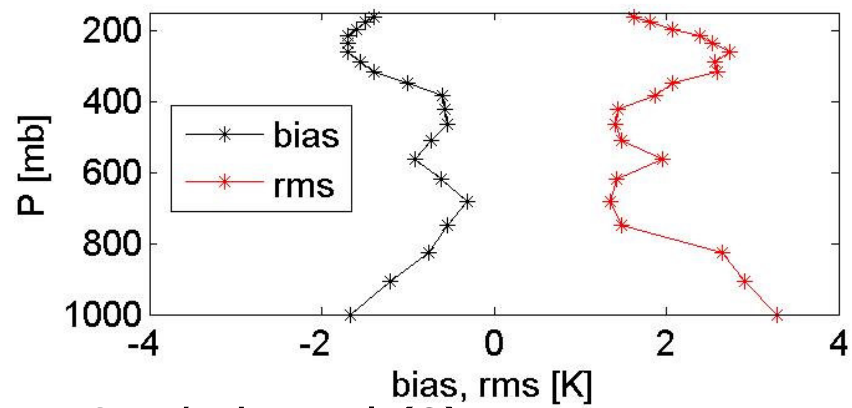
- Despite the difficulties of interpolation, what is shown next are the ensemble WAVES results for T, H_2O and O_3 for both AIRS and TES.
  - In the case of AIRS, results are compared at the pressure layers of AIRS
    - Placing on 1 and 2 km layers has bugs currently
  - In the case of TES, results are compared at pressure levels of TES with and without use of kernels.

WAVES ensemble temperature comparisons

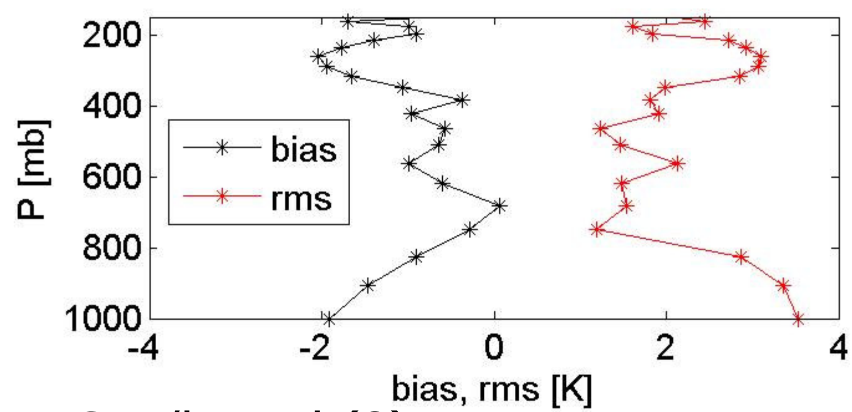
- Performed at the satellite retrieval pressure levels
  - 1 and 2 km averaging had obvious bugs so are not reported.
- All retrievals have tendency to run cold near the surface and in the UT
- The use of TES kernel functions does not affect the comparison significantly due to smooth nature of temperature profile



AIRS w/o kernel (23)



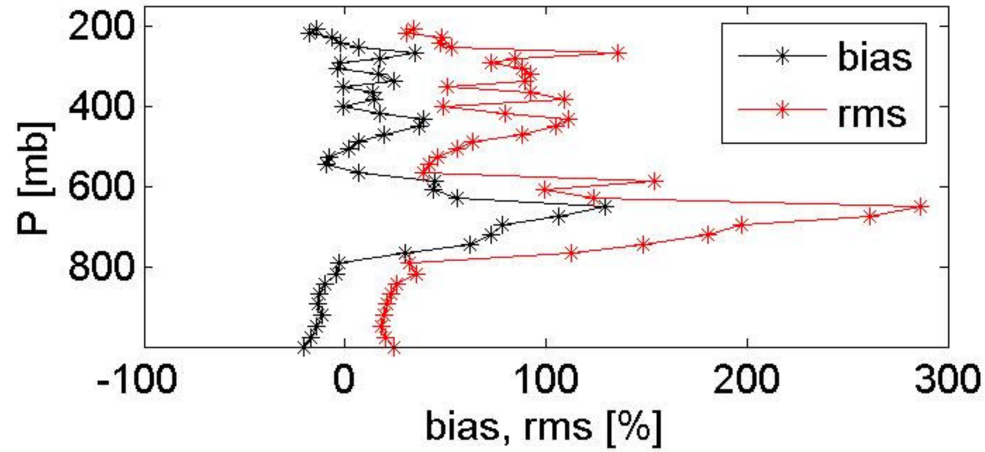
TES w/o kernel (8)



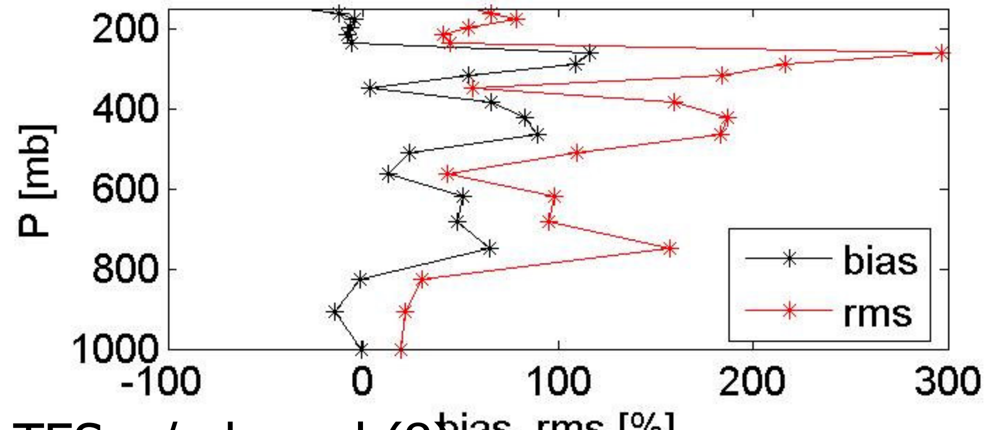
TES w/kernel (8)

WAVES ensemble water vapor comparisons

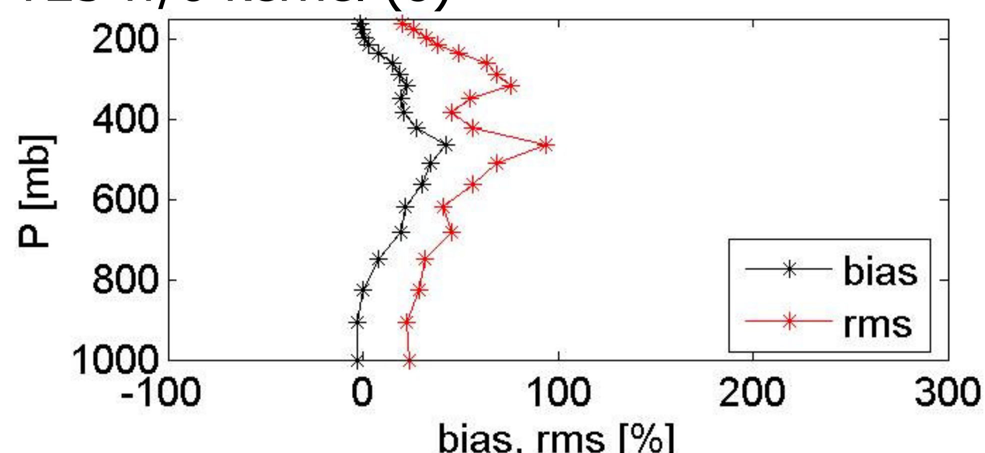
- TES shows better agreement with sonde than AIRS near the surface and in the 600-800 mb region but poorer agreement in the UT
- The use of TES kernel has dramatic effect on the comparisons unlike in the case of temperature because of much greater structure in the water vapor profile



AIRS w/o kernel (23)



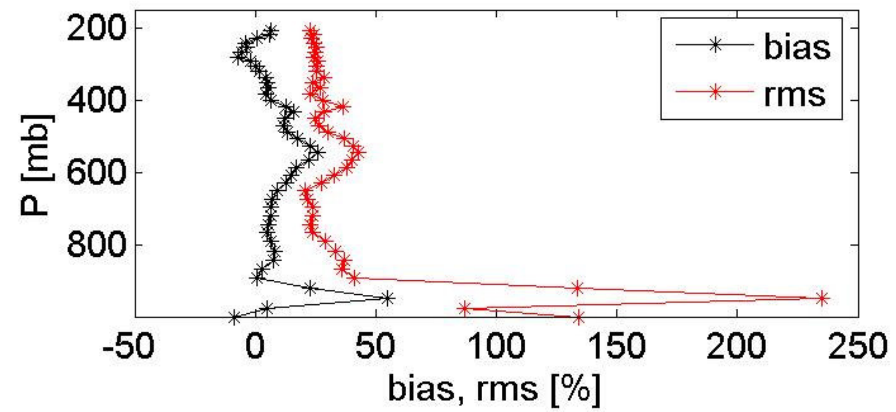
TES w/o kernel (8)



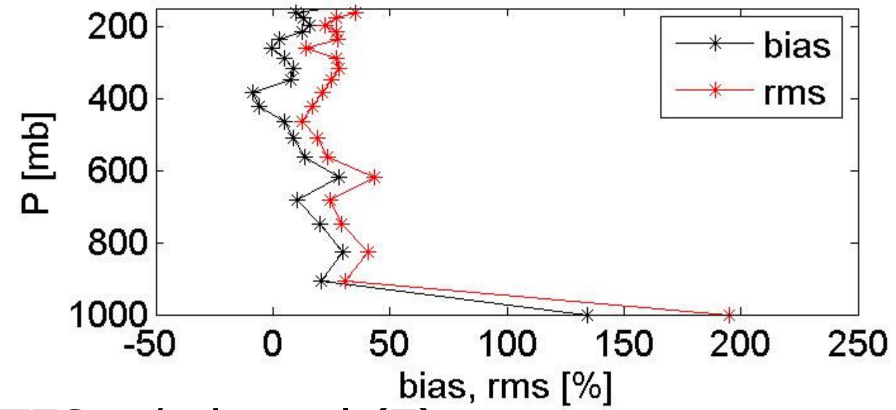
TES w/kernel (8)

WAVES ensemble ozone comparisons

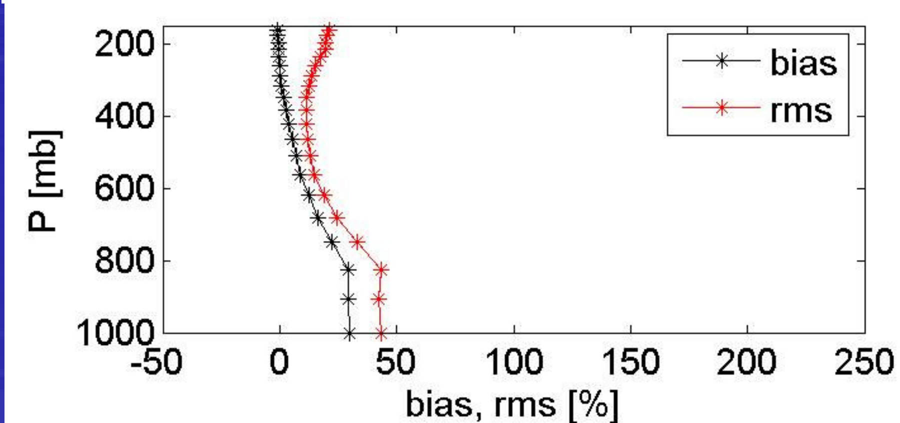
- AIRS shows generally better agreement with sondes than TES at all levels below 400 mb.
- Use of kernel functions for TES does not change that conclusion.



AIRS w/o kernel (20)



TES w/o kernel (7)



TES w/kernel (7)

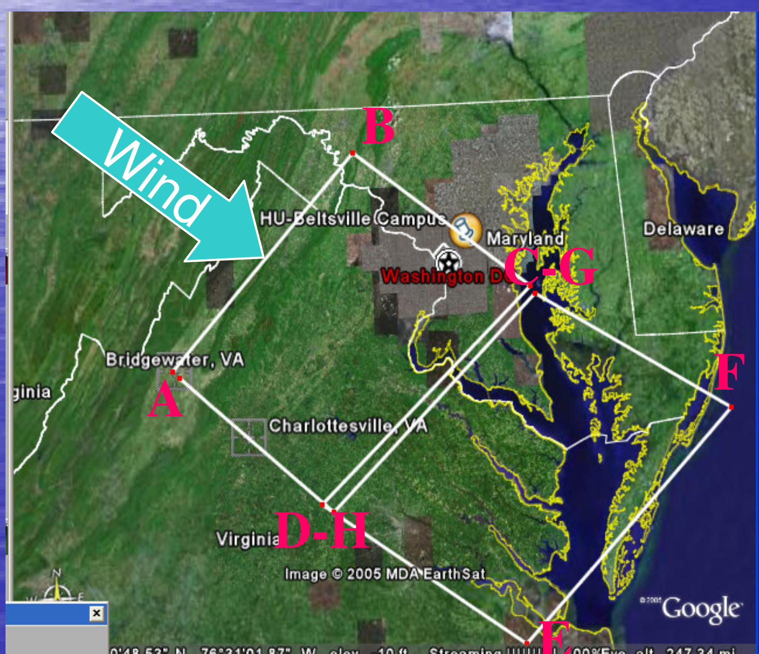
WAVES_2007

- July 14 – August 8, 2007
  - Fall component (dates TBD) for sampling in different season
- ~25 A-train overpasses to be targeted
  - Sonde (RS92 w/ECC), lidar
- IASI overpasses approximately 4 hours earlier
  - Target ~15 IASI overpasses where A-train overpasses 4 hours later are also good.
- Airborne component
  - Raman Airborne Spectroscopic Lidar (RASL) flying on KingAir for surveying regional variability in water vapor and aerosols during overpasses
  - 29,000′ maximum altitude
  - 700 nm range
  - ~200 nm/hr flight speed

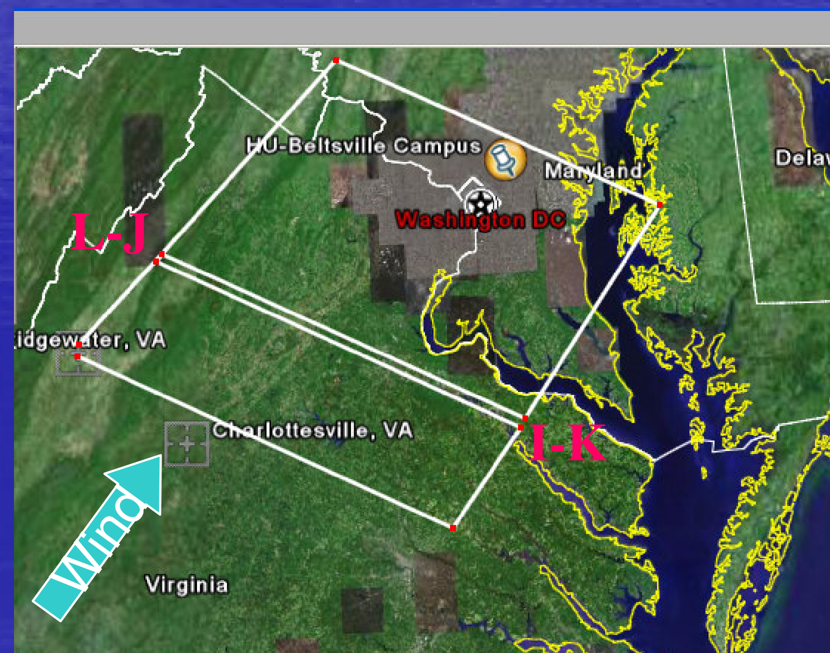
RASL on a Dynamic Aviation King Air (Bridgewater, VA)

WAVES_2007 Airborne Component

- Matrix of candidate flight missions being developed
  - AIRS/IASI validation (NOAA, Howard)
  - TES validation (JPL, AER)
  - Boundary layer evolution (GSFC, Howard)
  - Pollution transport for air quality analysis (NOAA/ARL, Howard, GSFC)
  - Aerosol modification (Howard)
  - CALIPSO under flight (GSFC, LaRC)
- Possible regional flight patterns shown below
- If you have interest in participating in planning an AIRS focussed mission (or other), please contact Chris Barnet or Dave Whiteman.



Total distance: 683 nm



Total Distance: 533 nm

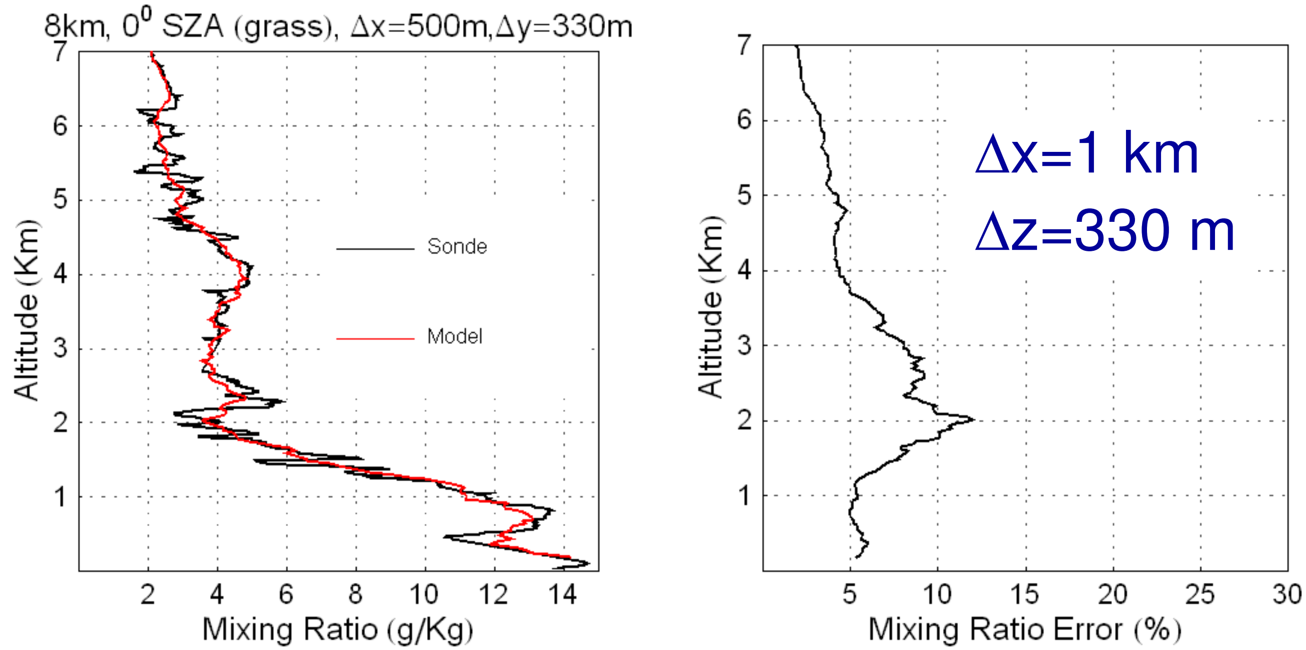
Questions?

Backups

RASL Airborne Simulations

- Quantities
  - Water vapor mixing ratio
  - Aerosol extinction
    - A surrogate for cloud CCN?
- Simulated parameters
  - Flight altitude 8 km
  - Averaging time
    - Water vapor - 10 sec
    - Extinction – (15, 60 sec)
- Errors
  - 5-10% (20%) for both water vapor and aerosol extinction

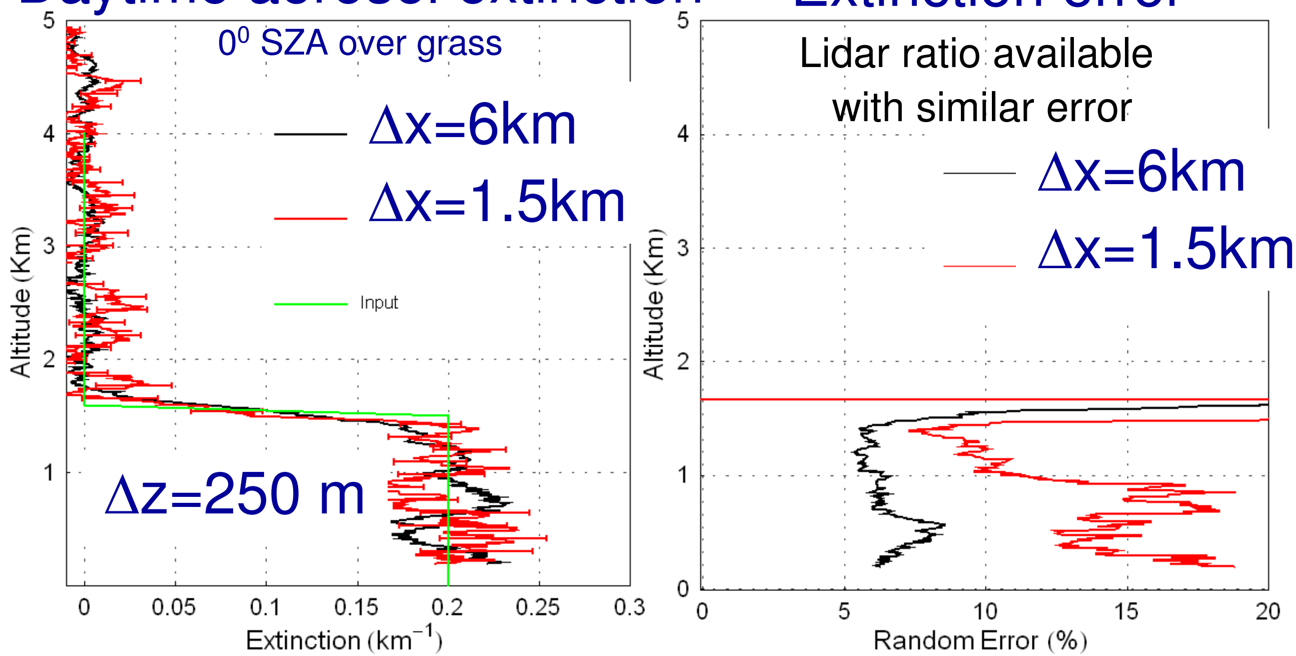
Appl. Opt. 40 (3), 375-390 (2001)



Daytime water vapor mixing ratio (10 sec)

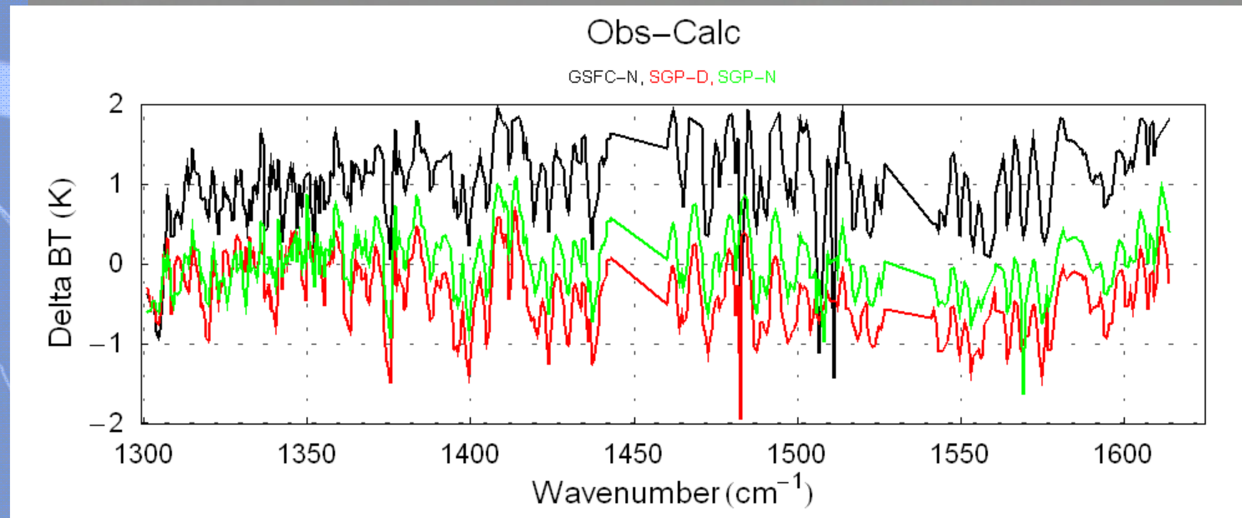
Daytime aerosol extinction

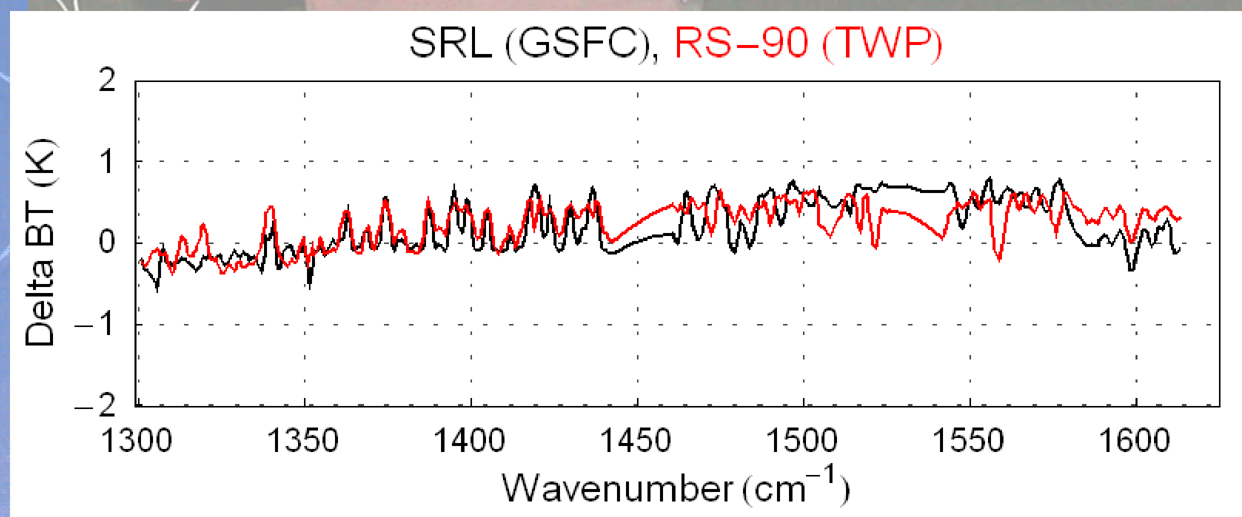
Extinction error



AIRS Water Vapor Experiment-Ground (AWEX-G)

- **Held at DOE/SGP in Oct-Nov, 2003**
  - **Various water vapor measurement technologies**
    - **Sondes: Vaisala, Intermet, Sippican**
    - **Cryogenic Instruments: CFH, SnowWhite**
    - **Lidars: CARL, SRL**
    - **Total column: MWR, GPS**
- **Results**
  - **Validation of empirical correction for Vaisala RS80 and RS90/92**
  - **Validation of physical corrections to Raman lidar**





Miloshevich, L. M., et. al. J. Geophys. Res., 111, (2006).
Whiteman, D. N., et. al., J. Geophys. Res., 111, (2006).